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SEXUAL DIMORPHISM IN SIZE OF ADULTS AND PUPARIA OF *TETANOCERA FERRUGINEA* FALLÉN (DIPTERA: SCIOMYZIDAE)

Sylvie Manguin

Laboratoire de Biologie Animale, Faculté des Sciences, 33, rue L. Pasteur, 84000 Avignon, France.

Abstract.—Adults and puparia of *Tetanocera ferruginea* Fallén are sexually dimorphic. In both stages, the size of the female is significantly greater than that of the male. Based on a biometric study, puparial length demonstrated that the sex of the adults could be estimated before emergence with an 80.4% precision. This information on sexual differentiation is important for field studies of populations of sciomyzid flies.

Key Words: Sciomyzidae, *Tetanocera ferruginea*, sexual dimorphism, size, adults, puparia

In general, numerous Diptera (Vargas 1968) and many other insects (Mellini 1973) show sexual dimorphism in the size of adults and immature stages. Usually, the male is smaller than the female. For the puparia, the determination or separation of sexes is based on few parameters: average weight (Féron and Serment 1963), color of the puparium (e.g. *Lucilia cuprina* Wiedemann (Whitten 1969)), examination after a nontoxic chemical treatment (e.g., *Musca autumnalis* De Geer (Tung et al. 1969)), external morphological characters (Kuitert 1975), or microscopic examination through the puparium (Cunningham 1966).

Other studies have shown that for Diptera, sexual dimorphism rarely appears among the larvae (Atchley 1971) and never in the eggs. However, dimorphism of larvae and eggs does occur in Homoptera (Monti 1955) and Lepidoptera (Levesque 1963).

The determination of sex of the immature stages of the Sciomyzidae is an important factor in studies of the basic biology of these flies. Sexual differentiation is particularly important for field studies of population dynamics of these flies, or when an intensive rearing program is part of a biological control project.

From 1982 to 1987, samples of sciomyzid species were collected periodically from an aquatic habitat near Avignon, in southern France. Studies revealed that there was a distinct variation in the size of adults and puparia of the species of flies, and particularly of *Tetanocera ferruginea* Fallén, which was the most common species in the sciomyzid population of this habitat (Vala and Manguin 1987).

MATERIALS AND METHODS

T. ferruginea has 3 or 4 annual generations (Vala and Haab 1984) and the flight period extends from late March through November. The species overwinters as diapausing puparia (Berg et al. 1982).

The puparium is black, oval, measuring 7.3 to 7.7 mm long and 3.1 to 3.4 mm wide (Fig. 1). The anterior part has the circular line of dehiscence for adult emergence. The raised posterior end has a vestigial respiratory disc and vestigial lobes of the third-instar larva. The spiracles are above the puparium, which is an adaptation for flotation.

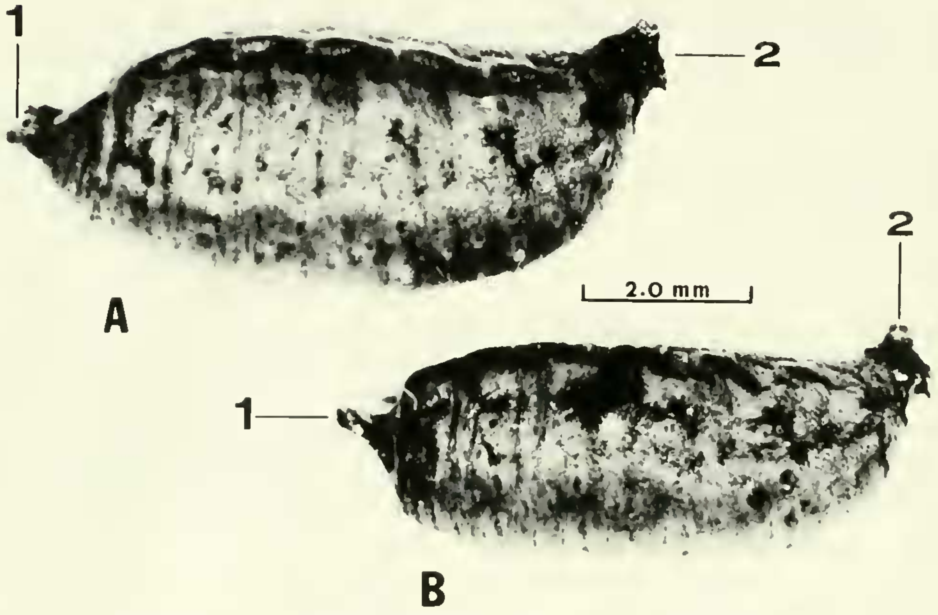

Fig. 1. Lateral view of the puparium of *T. ferruginea*. A, female puparium; B, male puparium. 1, anterior spiracle; 2, posterior spiracle.

The puparia examined were from laboratory cultures of *T. ferruginea* which were held in incubators at 20°C with a photoperiod of LD 16:8. The larvae were reared in petri dishes (17 cm diameter × 5 cm deep) with 5 mm of tap water, which contained one sciomyzid larva and 10 snails each of the species *Physa acuta* (Draparnaud) and *Lymnaea palustris* (Müller). These species of prey were readily attacked by larvae of *T. ferruginea* and 20 prey per unit were more than adequate for one larva (Manguin et al. 1986, 1988).

All specimens were measured with a 1/50 mm Kanon gauge. The length of the adults was measured from the frons to the terminalia; the width was the distance between the lateral margins across the median part of thorax. For puparia, three parameters were measured: length, width, and height. All measurements were of the distance between the extremities along or across the median part of the puparia. After measurements were taken the puparia were returned to the incubator and held for emergence of the adult to verify the sex of each specimen.

RESULTS

Sexual dimorphism of adults: Measurements of the length and width of 30 specimens of each sex produced a bimodal curve for the distribution of size. (Fig. 2).

Males, the smaller sex, represented the first peak of the curve, averaging 9.6 mm in length (range 7.9 to 10.5 mm) and 1.9 mm in width (range 1.6 to 2.5 mm). The larger females represented the second peak with an average of 10.9 mm in length (range 9.9 to 11.9 mm) and 2.2 mm in width (1.7 to 2.8 mm).

These two parameters showed highly significant differences between males and females ($P < 0.01$). However, the measurements of the sizes of males and females produced an overlapping zone which was narrower for length than for width.

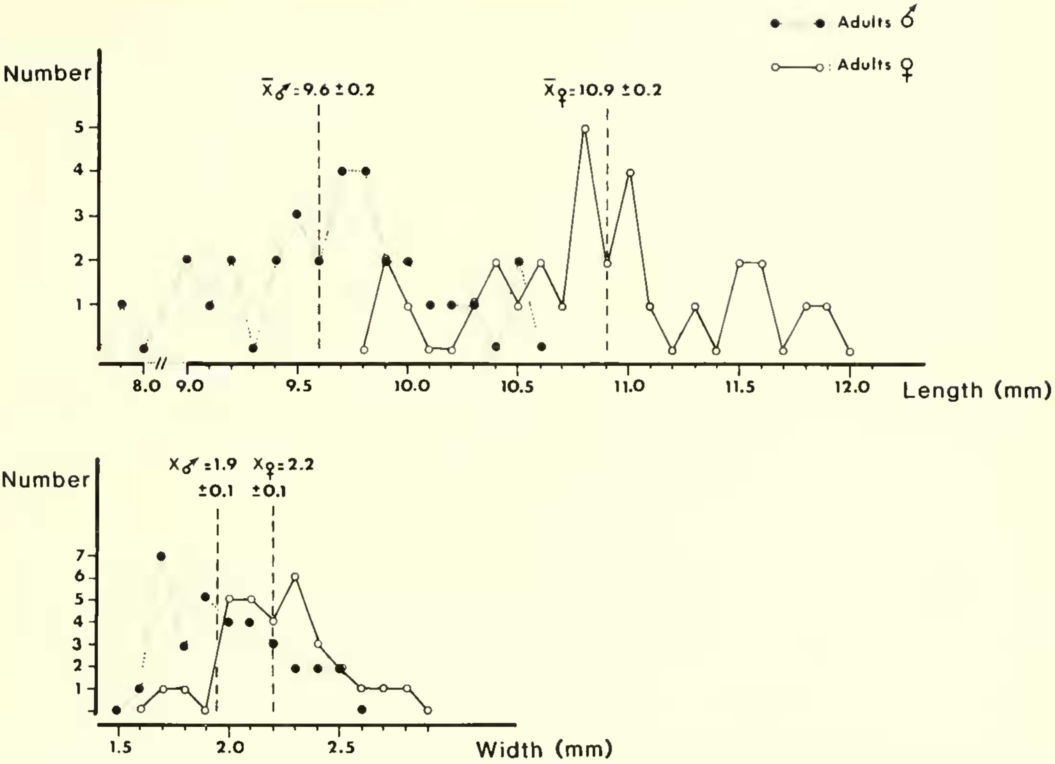

Fig. 2. Distributions of length and width (mm) of adults of *T. ferruginea*. Males = broken line, solid circle; females = solid line, clear circle; n = 30 specimens per sex.

Sexual dimorphism of puparia: We measured unemerged puparia for predicting the sex of an adult. After an adult had emerged, the empty puparium, minus the cephalic caps, again was measured for comparison with the observed sex of the adult specimen.

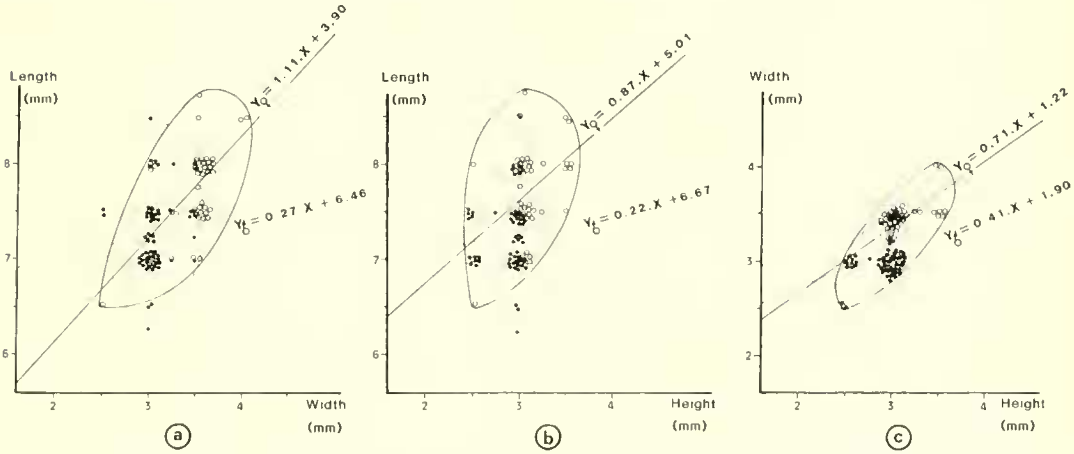

Fig. 3. Regressions between sizes and unemerged puparia of *T. ferruginea*. Males = broken line, solid circle; females = solid line, clear circle; a, length/width; b, length/height; c, width/height.

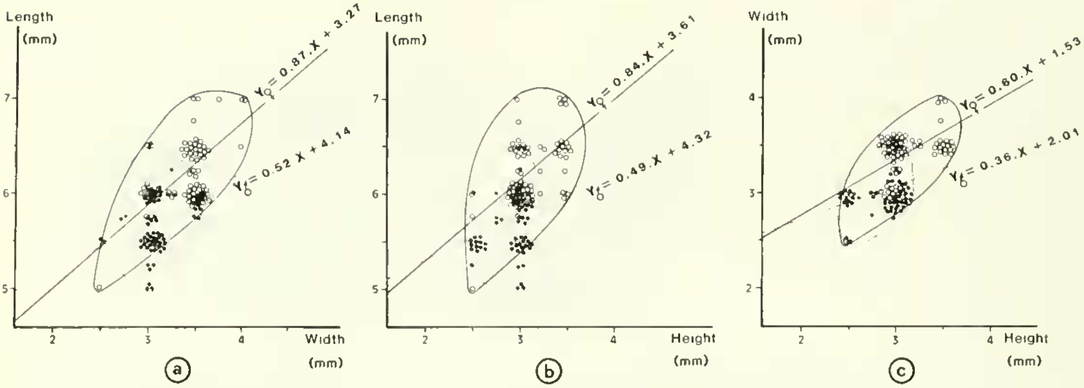

Fig. 4. Regressions between sizes of puparia of *T. ferruginea*. Males = broken line, solid circle; females = solid line, clear circle; a, length/width; b, length/height; c, width/height.

The results in Table 1 indicate that the size of the female puparium is significantly larger than that of the male ($P < 0.01$).

The size distribution was established by correlating paired dimensions of unemerged puparia (Fig. 3) and emerged puparia (Fig. 4). For males, the distribution of every measurement was narrow, regardless of the measurement considered. This was confirmed by the coefficient of variation which varied within narrow limits, from 5.6 to 7.1 (Table 1). For females, the data clusters on the graph were larger and defined a loose type of dispersion. The coefficient of variation was significantly higher and ranged from 5.9 to 8.5.

In superimposing graphs obtained for both sexes (Figs. 3 and 4), the dispersion of the data was unwedged, particularly when the length of the puparium was considered (Figs. 3a,b and 4a,b). The width and height were highly different between the sexes, but these differences were not as important as those determined for the length (Figs. 3c, 4c).

In general, the correlations obtained (Figs. 3, 4) were defined by equations in which the range slope varied between 0.22 and 0.52 for the males and between 0.60 and 1.11 for the females. These slopes, steeper for the females, revealed that the 3 parameters (length, width and height) evolved in a simultaneous manner. However, for males, the slopes were much more level and there was not much difference between parameters. Although the length increased, the width and height varied only slightly.

Table 1. Mean size (mm) in length, width, and height of male and female unemerged puparia and empty puparia of *T. ferruginea* (±standard deviation at 5% threshold). CV (%): coefficient of variation; n = number of measured puparia.

		Unemerged puparia			Emerged puparia		
		Length	Width	Height	Length	Width	Height
			n = 57			n = 72	
Males	$\bar{x}$ (mm)	7.3 ± 0.11	3.1 ± 0.06	2.9 ± 0.05	5.7 ± 0.08	3.1 ± 0.05	2.9 ± 0.05
	CV (%)	5.8	7.0	7.1	5.6	6.8	7.0
			n = 48			n = 71	
Females	$\bar{x}$ (mm)	7.7 ± 0.14	3.4 ± 0.08	3.1 ± 0.07	6.2 ± 0.09	3.4 ± 0.06	3.1 ± 0.06
	CV (%)	6.3	8.5	7.5	5.9	7.7	8.2

The length of a puparium was more definitive than either the width or height as a character to recognize the sex.

Estimation of the sex of the puparium: We measured the length of 240 unemerged puparia and estimated that 143 puparia would be male and 97 puparia would be female (Table 2). After adult emergence these predictions were proven correct in 80.4% of cases. The results were more reliable with males, with only 9.8% of error, whereas measurements of the females were 34% erroneous. This difference was explained by the larger spread of measurements for the female, shown by the coefficient of variation (Table 1).

Table 2. Estimation of the sex of puparia determined by the measurement of the length.

	Number Puparia Examined	Percentage Accuracy
Males	143	90.2
Females	97	66.0
Total	240	80.4

DISCUSSION

There is sexual dimorphism in sizes of adults and puparia of *T. ferruginea.* For adults, the length and width of the females was significantly greater than for males. Among the puparia, the parameters of length, width, and height increased proportionally for the females. Consequently, the shape of female puparia was more oval with the dorsal side slightly convex. For the males only the length of the puparia varied. The width and height were relatively constant; and in lateral view, the dorsal surface of the puparium was more rectilinear.

The possibility of determining the sex of the flies prior to emergence, with an 80.4% accuracy, is important not only for population studies of field collected material, but also for purposes of release in biological control programs. The sexual differentiation permits an easy manipulation of inert pupae rather than active living flies, and eliminates the need to hold for adult emergence if sampling only is required. An additional benefit of this method would be its use in the study of those parasites that emerge from puparia, such as many species of Ichneumonidae (Manguin 1987). By determining the sex of the puparia, the distribution of parasites emerging from male and female hosts can be established. This was not possible when the sex of the host was based only on the adult specimen.

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